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Challenge Athena II Analysis Results: EUCOM/CENTCOM Deployment of George Washington Battle Group (U)

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Desert Storm highlighted the need to improve our capability to transmit large volumes of digital imagery to afloat commanders. Project Challenge Athena I demonstrated the usefulness of commercial wideband satellites for delivering primary imagery products to an afloat unit. Project Challenge Athena II extended the concept to an operational environment. This demonstration used a duplex, high-volume commercial satellite to provide imagery and other services to the George Washington Battle Group during its 1994 Mediterranean/Persian Gulf deployment. This annotated briefing presents the results from Challenge Athena II.

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Contents

Preface

(U) This annotated briefing is a For-Official-Use-Only version of CNA Annotated Briefing 95-11, Challenge Athena II *Analysis Results: EUCOM/CENTCOM Deployment of* George Washington *Battle Group.* We removed classified viewgraphs and text from the original version, and inserted place holders to indicate where we made changes.

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Challenge Athena II: EUCOM/CENTCOM Deployment

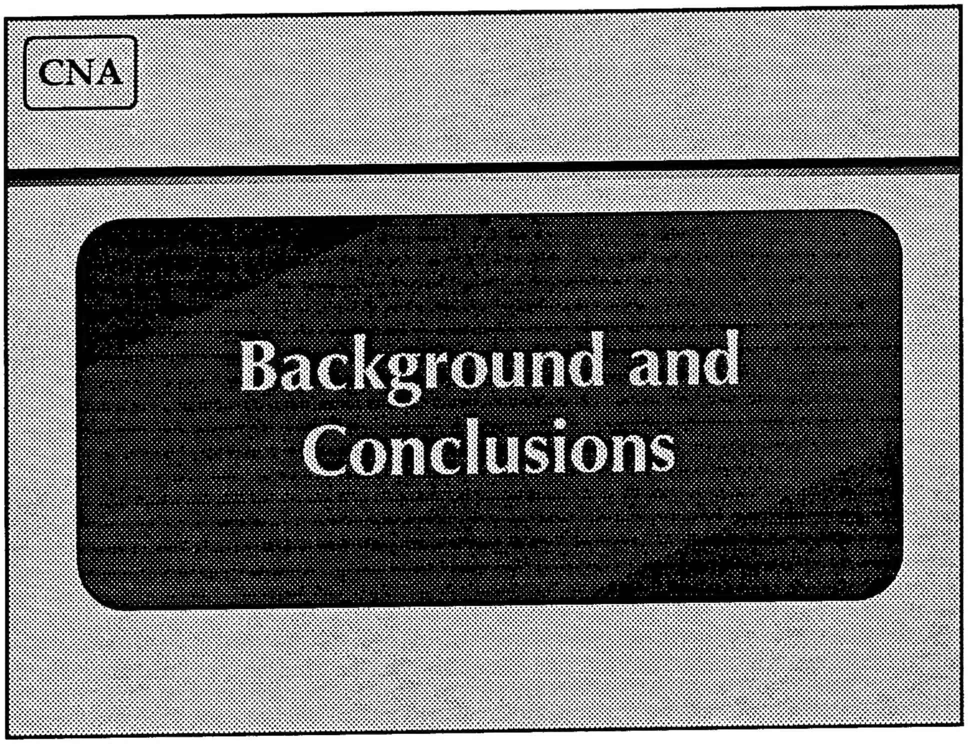
George Washington Battle Group

(U) Desert Storm highlighted the need to improve our capability to transmit large volumes of digital imagery to afloat commanders. Because today's fleet communication systems cannot meet current and future needs for timely, high-resolution imagery, the Director, Space and Electronic Warfare (N6), conducted Project *Challenge Athena I* on board USS *George Washington* (CVN-73) in September 1992. *Challenge Athena I* demonstrated the usefulness of commercial wideband satellites for delivering primary imagery products to an afloat unit [1].

(U) Project *Challenge Athena II* extended the concept to an operational environment. This demonstration used a duplex, high-volume commercial satellite to provide imagery and other services (e.g., televideo applications) to the *George Washington* battle group during its 1994 Mediterranean/Persian Gulf deployment.

(U) This annotated briefing[1] presents the results from *Challenge Athena II* during the deployment of the *George Washington* battle group between May and November 1994. A previous annotated briefing [2] presents the results from phase I, the battle group's predeployment FleetEx conducted in April 1994. The demonstration plan [3] contains a complete description of *Challenge Athena II*.

1. The authors acknowledge the contribution of Mr. Ed Engle for his efforts in the development of this annotated briefing.



(U) This briefing comprises four sections plus supporting appendices. The first section provides a brief background on *Challenge Athena II* and summarizes the demonstration. The second section discusses issues related to the transmission element—the components and systems that together create the communications path between *George Washington* and other nodes. The third section looks at the operational element—the user applications that share the *Challenge Athena* bandwidth and their value to the battle group. The final section presents suggestions for building on *Challenge Athena's* success in the future.

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Context

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Challenge Athena II

- Operational demonstration
  - » On board *George Washington* for entire Mediterranean/ CENTCOM deployment
- Commercial SATCOM connectivity afloat
  - » Large bandwidth
  - » Value-added
- Dynamic bandwidth management
  - » Demonstration of N6's Copernican concept
  - » Flexible, controlled by end-user (*George Washington*)
  - » Many applications

(U) The impetus behind *Challenge Athena II* was to deliver national imagery routinely to an afloat user under operational conditions. The focus was not on the technical capability—*Challenge Athena I* showed that—but on whether the carrier could receive and use large quantities of imagery, do it in a timely manner (tactical utility), and sustain the process throughout the deployment.

(U) *Challenge Athena II* used a duplex, high-volume commercial satellite channel with T1 bandwidth (1.544 Mbps). Half of the bandwidth (772 kbps) was used for imagery; the other half was used for telemedicine and telecommunication applications. This division allowed users to receive large images in a tactically relevant time frame, such as may be required for battle-damage assessment, while still providing excess capacity for other applications. Our analytic focus was the tactical utility or value-added of the services provided by the *Challenge Athena II* connectivity.

(U) *Challenge Athena II* also was an operational, afloat demonstration of dynamic bandwidth management. This keystone of the Copernican concept advocates flexible communication circuits to optimize the use of communication resources by eliminating dedicated "stovepipes." A TIMEPLEX multiplexer on *George Washington* allowed the carrier to allocate the *Challenge Athena* bandwidth among multiple circuits as current priorities dictated. Although this action required keyboard entries by a radioman, an SHF satellite link backup feature was automatic—accomplished by the TIMEPLEX itself within seconds of an SHF link failure.

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Conclusions

Challenge Athena II successes

- System was reliable; no significant downtime
- Deployed CVN received large quantities of imagery
- Copernican concept of dynamic bandwidth management demonstrated
- Able to monitor events in multiple regions simultaneously
- Greater communications capability benefited deployment

(U) *Challenge Athena II* was a success in all objective areas: maintaining reliable connectivity, demonstrating dynamic bandwidth management afloat, and supporting real-world battle group operations with primary imagery and other telecommunication services.

(U) The system was reliable. We discuss downtimes later in the paper, but they were intermittent and short, measured in minutes. Electromagnetic interference (EMI) occasionally jammed transmissions, but primarily came from known sources (SPS-48, SPY-1, and pirate radio stations along the Mediterranean littoral).

(U) This paragraph has been removed. Please refer to the complete (and classified) version of CNA Annotated Briefing 95-11.

(U) *George Washington* also demonstrated dynamic bandwidth management. Bandwidth reconfigurations were done routinely without affecting users not explicitly part of the reallocation. Switches between the existing ship-SHF circuit and the *Challenge Athena* bandwidth occurred automatically and were transparent to SHF users.

(U) Tactically, *Challenge Athena* allowed the battle group to monitor events in multiple regions. It received daily images, but also was able to monitor both EUCOM and CENTCOM message broadcasts when preparing to move from one theater to the other (a move that occurred four times). This capability boosted the battle group's ability to plan contingencies (e.g., an NEO in Algeria), support other forces (e.g., MEUs going to Somalia), and update target folders for any area in which the carrier might operate.

(U) Better telecommunications provided additional benefits. For example, medical care improved as a result of consultations with a shore facility, and crew morale rose as a result of inexpensive phone service.

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Comments and reviews

- RAdm Krekich (COMGWBATGRU):
  Challenge Athena II provides a
  "...complete ticket at the table of jointness."
- CVW-7:
  Challenge Athena II offers a
  "...unique capability unavailable from secondary imagery."
- *George Washington*'s medical department:
  "There is no doubt that this system works and was of great benefit and assistance during the deployment."
- Overall assessment:
  "Two thumbs up!"

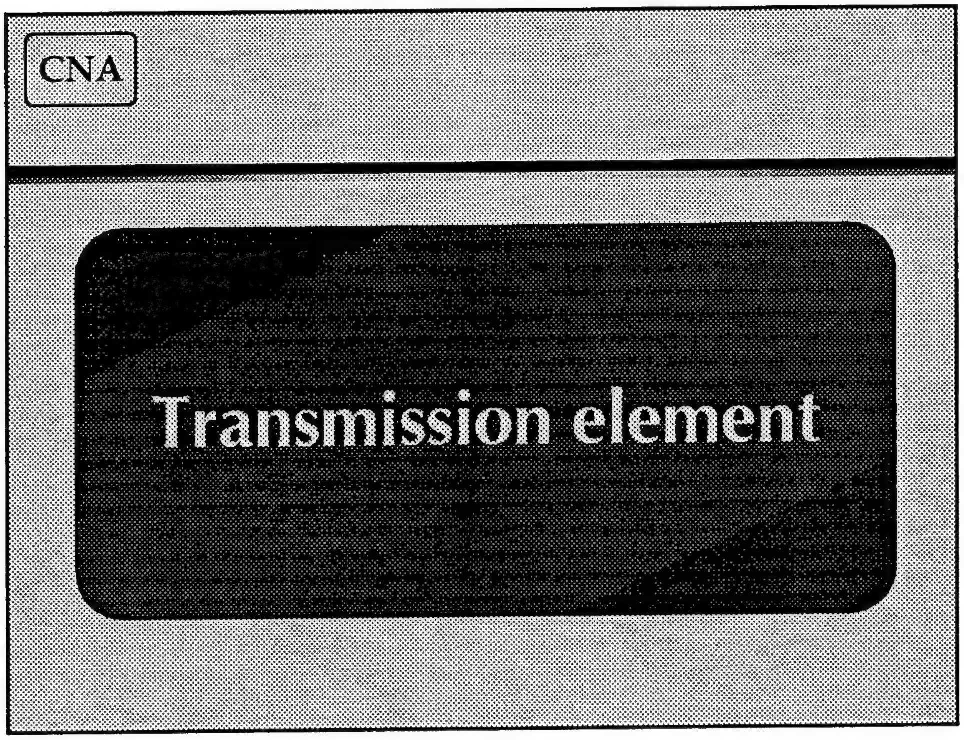
(U) Here is a sampling of comments from the users of *Challenge Athena* applications. These comments represent the responses gleaned from data-collection forms and questionnaires.

(U) **RAdm Krekich** believes connectivity like that provided during *Challenge Athena* is necessary for the Navy to be a full player in joint operations. He and his staff monitored events in five disparate regions in two theaters of operation. The admiral also praised the ability to obtain recent, high-quality imagery.

(U) **Commander, Carrier Air Wing Seven,** liked the image mensuration and manipulation available from primary imagery. He felt that secondary imagery does not provide adequate resolution to discern detailed information and that strike missions can be prepared more effectively using primary imagery.

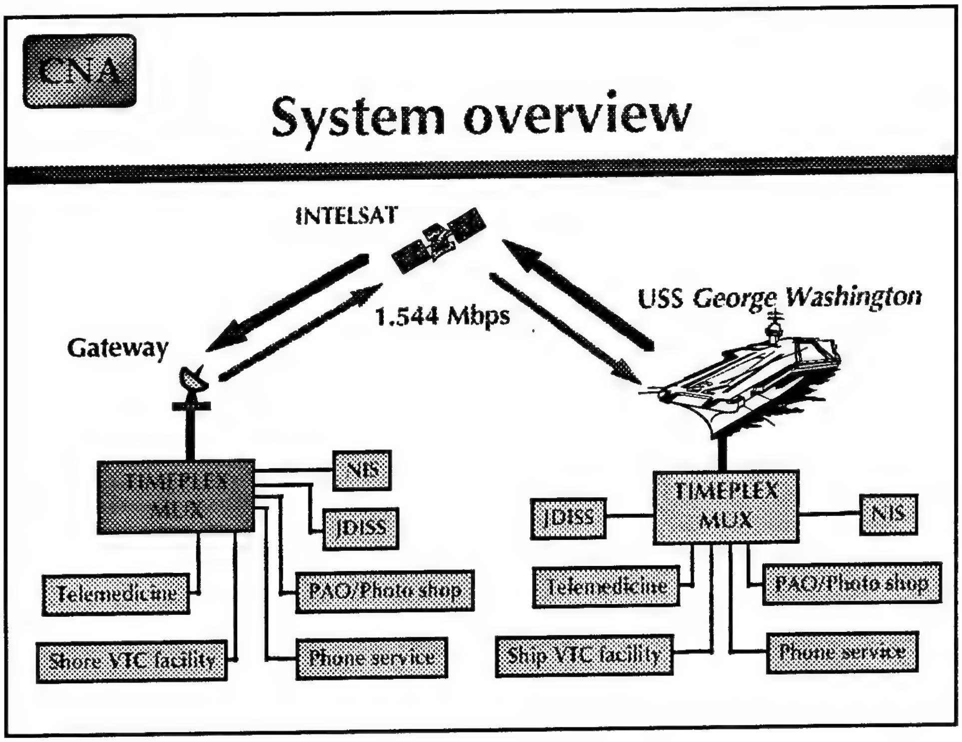
(U) The **medical department on *George Washington*** also was pleased. With direct consultations from Naval Hospital, Bethesda, doctors reduced the number of medical evacuations (MEDEVACs) by 40 percent relative to the number a typical carrier would experience on deployment. In the process, they diagnosed several early cases of cancer that ordinarily would not have been discovered until they had become more serious.

(U) The overall conclusion from all participants we heard from is that *Challenge Athena II* was an unequivocal success. The demonstration went extremely well, and the applications worked as advertised. Some technical problems occurred—which is inevitable on a project of this scale—but expertise ashore and innovation afloat prevented significant interruptions of the demonstration.



(U) The transmission element refers to the hardware and technical specifications of the *Challenge Athena II* communications pathway. It includes all the components and subsystems that together provide connectivity between end-users. This element does not include user applications, which merely use the pathway.

(U) In this section, we discuss how well the communication path worked. We point out issues related to system reliability, dynamic bandwidth management, EMI, antenna configurations, and edge effects. Individual applications and the information they carry between users are discussed in the section on the operational element.



(U) The above figure summarizes the communications pathway between users at shore facilities and users on *George Washington.* The focal points are the TIMEPLEX multiplexers at the Naval Communications Detachment (NAVCOMDET) in Norfolk, Virginia, and in the communications room of the carrier.

(U) Each facility that is allocated part of the *Challenge Athena* bandwidth sends a signal (usually over a landline) into the multiplexer at NAVCOMDET. This multiplexer combines the signals and forwards the combined bandwidth, also over a landline, to the CRESCOM, Inc., commercial gateway in Holmdel, New Jersey. This gateway transmits the combined bandwidth to an INTELSAT satellite, which relays it to *George Washington.* The multiplexer on the carrier then separates the signals from the shore facilities and routes each to the appropriate afloat user. Afloat signals follow the reverse path to the shore facilities.

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System reliability

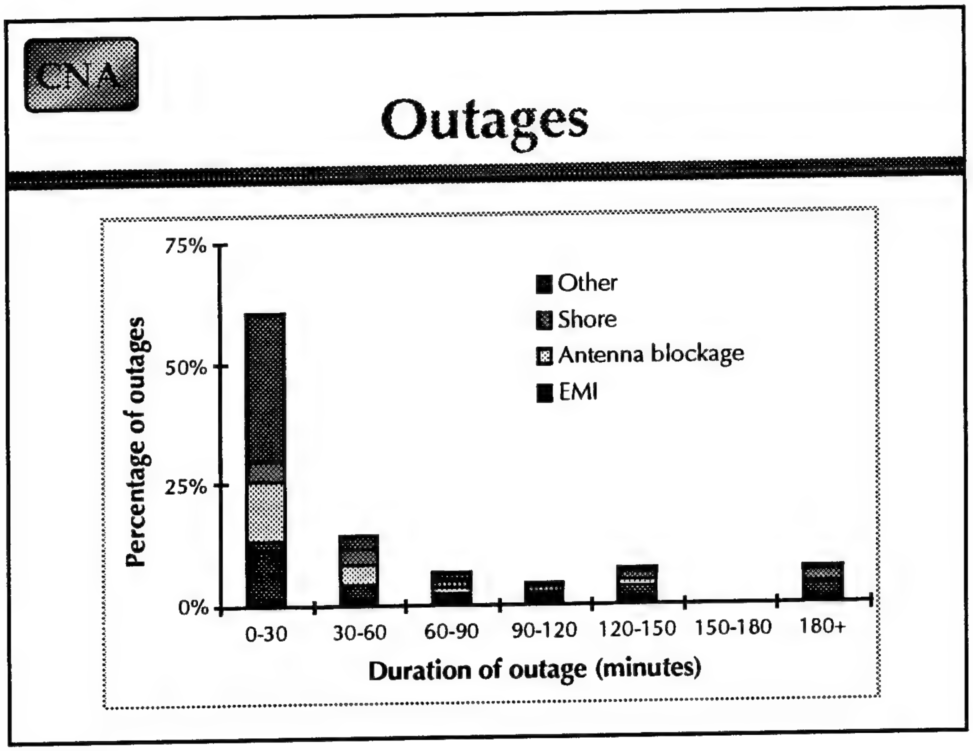
- 96% comms circuit availability
  - » Measured from ship logs
  - » 75% of outages lasted less than 1 hour
  - » EMI and antenna blockage were primary causes of outages
- BER on order of 10^{-6} (with no EMI)
- Multiple operating areas in two theaters
- Changed gateway with no effect on operations

(U) *Challenge Athena* connectivity was reliable throughout the deployment. From 20 May to 29 October, *George Washington* recorded 122 periods of downtime, totaling 160 hours. This downtime equates to a measured system availability of 96 percent. The median downtime was 20 minutes, with 91 outages (75 percent) lasting less than 1 hour. Only 6 outages (5 percent) lasted more than 4 hours. For this brief, downtime refers to the *Challenge Athena* communications path, and not individual applications. We did not examine downtimes for specific applications.

(U) We divided the causes of downtime into four categories: EMI, antenna blockage, problems at shore facilities (e.g., NAVCOMDET or the gateway at Holmdel), and other. This last category includes those outages on *George Washington* (e.g., to reset the TIMEPLEX or realign the antenna); outages due to weather, atmospherics, or a low signal-to-noise ratio; and those with unknown causes or that did not clearly belong to another category. Appendix A lists the outages.

(U) EMI (34 outages, 51 hours) and antenna blockage (25 outages, 17 hours) were the most frequent causes of downtime. In particular, these caused 18 of the 31 outages (58 percent) that lasted more than 1 hour. Because the EMI came primarily from SPS-48 or SPY-1 radars, the battle group had control over the most common sources of downtime. We discuss EMI in more detail later.

(U) Problems ashore (17 outages, 61 hours) were less frequent and tended to be isolated incidents. Most (14 of 17, or 82 percent) lasted less than 2.5 hours. The few exceptions were as follows: a timing problem at the Holmdel gateway from 9 to 12 July resulted in four outages, totaling 41 hours of downtime, and a bad antenna coupler resulted in 8 hours of downtime on 4 August. If we do not include these isolated incidents, only 12 hours of downtime were specifically identified as the result of problems ashore. We note, however, that inadequate network training at shore facilities did result in specific applications (e.g., JDISS) experiencing downtime even though the *Challenge Athena* broadcast was up and servicing other applications.



(U) The *other* outages (46 outages, 31 hours) typically were of short duration. A burned-out high-power amplifier on *George Washington* resulted in a 15-hour outage on 5 September, but most outages (38 of 46, or 83 percent) lasted 30 minutes or less.

(U) Throughout the deployment, ship personnel monitored bit error rates (BERs). The BERs were on the order of 10^{-6} for much of the demonstration. This rate is close to the minimum required to receive imagery, but more than adequate for voice and video applications.

(U) For comparison, stationary commercial systems typically operate with 98 percent availability and BERs on the order of 10^{-8}. The values for *Challenge Athena* compare favorably because *George Washington* was not a stationary receiver. *George Washington* used several satellites and moved about extensively within the satellite footprints in two theaters of operation.

(U) The original plan called for all transmissions to *George Washington* to pass through the CRESCOM, Inc., commercial gateway at Holmdel, New Jersey. Technical problems, however, prevented the gateway from accessing the satellite that supported *George Washington*'s first incursion into the Persian Gulf. As a result, *Challenge Athena* communications were rerouted through the MCI gateway at Andover, Maine. Later the gateways were changed back. The system maintained its reliability throughout these gateway switches.

Dynamic bandwidth management

- Cornerstone of Copernican architecture demonstrated
- Bandwidth allocation controlled by *George Washington*
- Considerable flexibility
- Many applications on one comms path
- Smooth transitions

(U) *Challenge Athena II* was an operational, afloat demonstration of dynamic bandwidth management. This cornerstone of the Copernican concept for future communications advocates the elimination of dedicated stovepipes in favor of flexible systems that multiple users can share.

(U) TIMEPLEX routers on *George Washington* and at NAVCOMDET allocated the *Challenge Athena* bandwidth among multiple applications. Control of the bandwidth configuration resided on the carrier, which allowed the battle group commander to regulate how afloat users accessed the system and to reconfigure the system to meet the battle group's needs. Some coordination with NAVCOMDET, however, was necessary to maintain consistent configurations on both TIMEPLEX routers.

(U) Bandwidth management let *Challenge Athena* provide a backup to the carrier's existing SHF circuit. When the existing onboard circuit went down, the bandwidth was reconfigured to provide the same function. This management also allowed telephone, video-teleconferencing, and medical imagery systems to timeshare the bandwidth.

(U) Transitions between old and new bandwidth configurations became routine and were transparent to applications not specifically affected by the changes. Some reconfiguration attempts encountered problems, which *George Washington* traced to TIMEPLEX errors at NAVCOMDET. Interviews with ship personnel indicated that the problems decreased in frequency as the deployment went on. We believe these were "learning curve" experiences (both on board *George Washington* and ashore) and not indicators of long-term systematic problems.

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EMI

- SPS-48
  - Problem solved by installing notch filter after *George Washington* FleetEx
- SPY-1
  - No good solution found
  - Limited success with radar-sectoring and ship separation
- Local TV and microwave systems
  - Problem when operating near land

(U) EMI was the most frequent cause of system downtime. Based on previous demonstrations, the SPS-48 on the carrier and the Aegis SPY-1 were known sources of EMI. Local television and microwave systems also were occasionally a problem when the carrier operated close to land (e.g., in the Adriatic Sea, in the Red Sea, and in port at Corfu, Greece). Following *George Washington's* Normandy celebration in June (the 50th anniversary of D-Day), a low-pass filter was installed to block EMI from the SPS-48. This filter eliminated any further interference from the SPS-48, except when the radar operated in emergency power mode (e.g., "burnthrough"). Appendix B contains more detail about EMI.

(U) No satisfactory solution was found for the SPY-1 EMI. Observations by ship personnel indicate the SPY-1 can interfere with *Challenge Athena* at ranges up to 25 n.mi., but no orderly testing was done to determine the severity of the problem. Maintaining ship separation kept SPY-1 EMI to acceptable levels, but placed restrictions on where the Aegis ship could operate relative to the carrier. Attempts to sector radar emissions to avoid illuminating *George Washington* met with only partial success. A postdeployment evaluation of the received signal data suggests the SPY-1 may have been illuminating *George Washington* despite the restriction.

(U) Various ideas for minimizing SPY-1 EMI are being considered. One restricts the frequency bands used by the radar, but how this might affect radar performance is unclear. Another places small disks of radar-absorbent material (RAM) around the *Challenge Athena* antenna to reduce the effect of off-boresight interference from the SPY-1. This method might suppress interference by as much as 6 dB. Yet another idea uses a better radome that blocks radiation at low elevation angles. Such a radome might block SPY-1 emissions without affecting the signal to and from the satellite. Another solution uses Reed-Solomon encoding, instead of the Viturbi type that was used exclusively during *Challenge Athena II*. Other applications of RAM are being investigated as well. A structured test program may be required to determine the full extent of the SPY-1 EMI problem and to identify which solutions are most effective at reducing it.

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Other system issues

- Antenna issues
  - Cable unwrap
  - Placement
  - May lose satellite track during ship power outage
- Edge effects
  - No problems observed during demo
  - Five switches among three satellites
  - Advanced coordination required; business hours EST

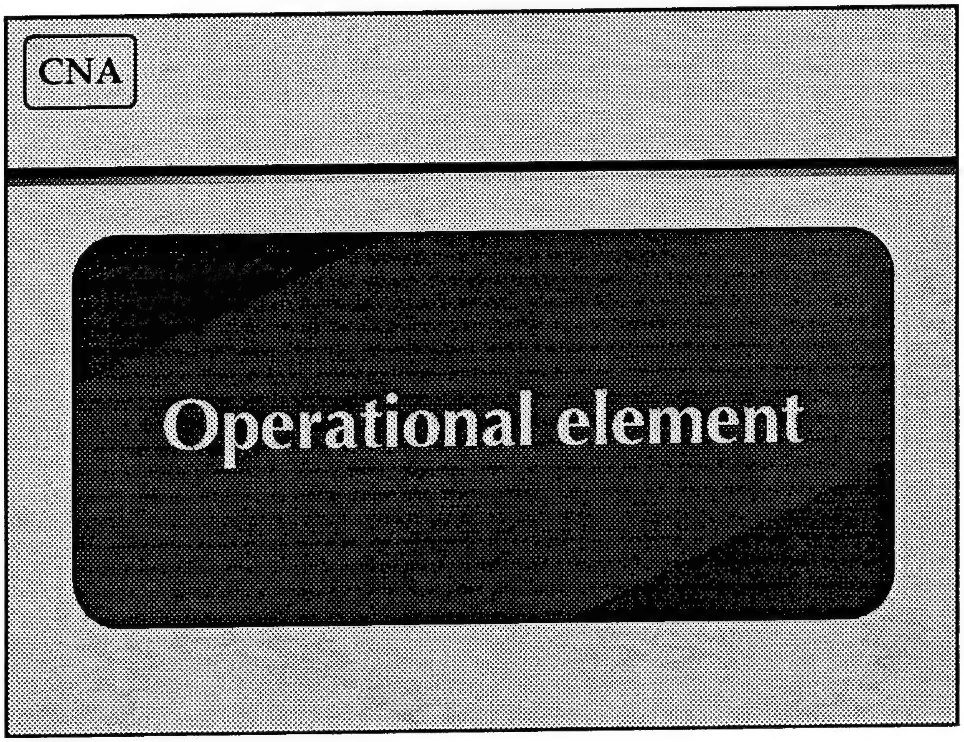
(U) The *Challenge Athena* antenna is connected to *George Washington* by a cable that wraps as the antenna turns. A 540-degree turn fully wraps the cable around the antenna. The antenna must then turn to unwind the cable. The process is automatic and lasts for only a few minutes, but the connectivity is broken until the antenna can regain the satellite. This feature caused a problem during the *George Washington* FleetEx when the unwrap interrupted several video teleconferences (VTCs). *Challenge Athena* ship-riders developed a "whiz-wheel" to help the ship avoid a maneuver that would trigger an unwrap. Although successful, this workaround restricted the carrier's movement. Future antenna designs will incorporate slip-ring technology to eliminate the need to unwind the cable.

(U) Future *Challenge Athena* demonstrations will have multiple ships sharing the bandwidth. Therefore, some form of "net control" will be required. Optimal antenna placement on command and major amphibious ships is an issue. For example, amphibious ships have no room remaining on their islands and cannot have sponsons attached because they need to be able to transit the Panama Canal. New technologies (e.g., smaller dishes) may allow greater flexibility in placing the antenna.

(U) In principle, the uninterrupted power supply (UPS) for *Challenge Athena* allows communications to be maintained during ship power failures. During one power outage drill, however, the antenna lost track of the satellite. Apparently, the antenna tracking is tied to the ship's gyro, which does not have UPS.

(U) *George Washington* observed no effects from operating on the edge of a satellite's footprint during its five satellite switch-overs. The carrier, however, did not attempt to operate on the extreme edge of any footprint for any length of time. This remains an issue for the future. The ability to operate on the edge of a footprint might affect how multiple ships in a complex operation would share multiple satellites.

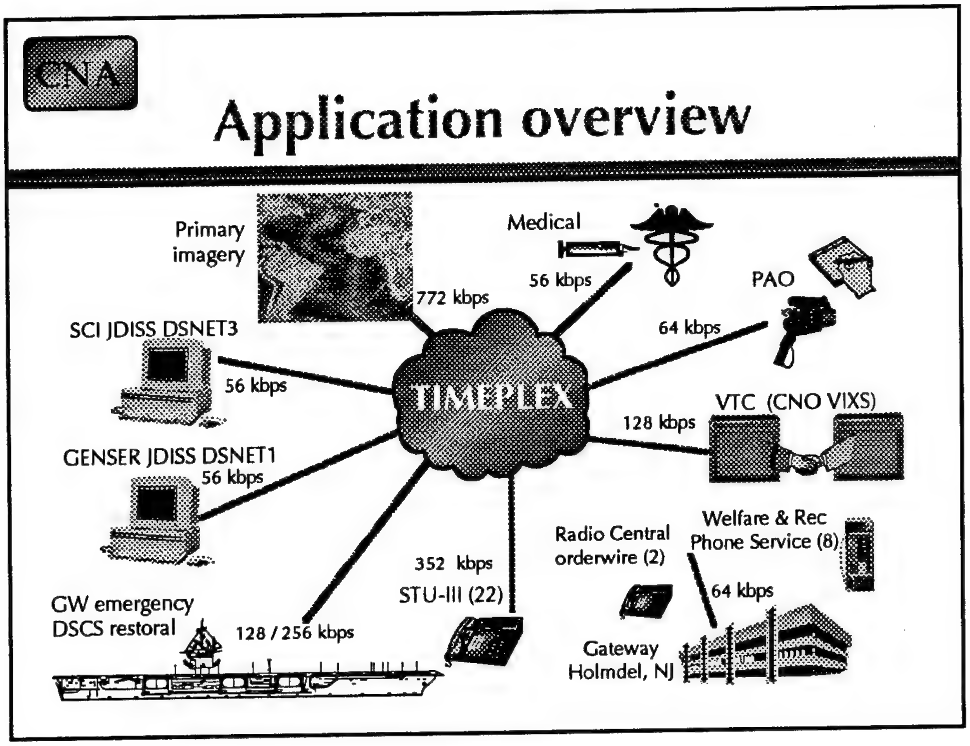
(U) Switching satellites was straightforward, but required advance coordination with the gateway. *George Washington* recommended switching during EST business hours to ensure the right people are there to handle problems. A 24-hour switching capability at all gateways is required if the Navy wants to use commercial satellites worldwide.



(U) The operational element refers to the applications used and to the information passed over *Challenge Athena*. In this section, we discuss each application and the value it brings to the battle group. Our emphasis is on what *Challenge Athena* provided that would not have been available otherwise.

(U) The original emphasis of the *Challenge Athena* demonstrations was the timely receipt of large quantities of primary imagery to afloat units. Wideband communication using commercial satellites was seen as a way to provide imagery for future systems such as the TLAM APS. Since the first demonstration, the focus has broadened to include greater communications in general. These communications include telemedicine, improved telephone and video teleconferencing, and the capability to support a CJTF or JFACC afloat. Although the demonstrations have not yet incorporated the latter capability specifically, many of the capabilities demonstrated during *Challenge Athena II* are steps in that direction.

(U) We begin with a summary of the applications used during *Challenge Athena II* and then discuss each in turn. Because imagery was the original impetus for the demonstration, we discuss it in more detail than the other applications. We note, however, that the telecommunication applications are being used increasingly to justify the connectivity, regardless of whether imagery is included.



(U) This slide shows all the applications that shared the *Challenge Athena II* connectivity path. The following list of applications and objectives ranges from tactical to administrative:

- Primary imagery—Routinely received large quantities of high-quality data on an afloat unit throughout the battle group deployment
- Medical imagery—Sent X-ray images back to Naval Hospital, Bethesda, for consultation and received annotated replies
- Video teleconferencing—Allowed better interaction between the battle group staff and other commands
- Telephones—Provided inexpensive, reliable telephone service for both official calls and personal calls from the *George Washington* crew
- *Challenge Athena II* JDISS—Provided a Genser JDISS capability for sending organic imagery (e.g., TARPS) to other users, and an SCI JDISS capability operating at 56 kbps (instead of the existing SCI JDISS at 9.6 kbps)
- DSCS restoral—Backed up the carrier's existing SHF circuit.

Each application performed well and provided the battle group with new or improved capabilities.

Tactical value-added

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Imagery overview

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A day in the life–16 June 1994

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Time-lates for EO images

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Time-lates for SAR images

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Time-lates for IR images

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Primary vs. secondary

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Flawed images

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Telemedicine

- Allowed specialty consultations and reading of X-rays by a CONUS-based medical facility
- Details
  - 105 patients evaluated
  - 259 images transmitted
    - Includes X-rays, EKGs, patient summaries, lab data
- Benefits
  - Cut number of MEDEVACs by 40%
  - 31 MEDEVACs avoided → $$$ savings
  - 6 early detections of cancer

(U) *George Washington*'s medical goals were to use *Challenge Athena* to avoid unnecessary MEDEVACs and to get consultations from shore (in this case, National Naval Medical Center, Bethesda). The E-systems PACSPRO laser film scanner installed in the medical department was a success. The equipment allowed doctors on *George Washington* to consult with specialists ashore and to send and receive X-ray images.

(U) Overall, 105 patients were evaluated using telemedicine during the deployment and 259 images were transmitted to Bethesda. The images consisted mostly of X-rays, but also included patient information (e.g., lab data) and EKGs (5 heart patients).

(U) In all, 31 MEDEVACs were avoided, which represents a reduction of about 40 percent from the number of MEDEVACs expected for a Mediterranean carrier deployment. About half of the MEDEVACs that could not be avoided were psychiatric evaluations. In the future, video teleconferencing may accomplish such evaluations without a MEDEVAC, which would reduce the number of MEDEVACs even further.

(U) The doctors on *George Washington* believe that the money saved by avoiding 31 MEDEVACs more than paid for the cost of the computer equipment. In truth, actual cost savings from the reduced MEDEVACs are difficult to determine. Cost estimates for a MEDEVAC range from less than $1,000 to over $3,000, depending on how readily the patient can be removed from (and eventually returned to) the carrier, and where the patient needs to go for treatment. These estimates suggest potential savings on the order of $30,000 to $60,000. Because a patient treated on board returns to work sooner than one evacuated, additional savings result from fewer missed work days and the avoidance of other intangible costs, such as finding or training a replacement worker. Telemedicine also led to the early detection of cancer in six patients. Early detection increases the likelihood of a successful treatment and recovery, another benefit that is difficult to quantify.

CNA

Video teleconferencing

- Better staff-to-staff interactions
  - Face-to-face vs. record message traffic
- *George Washington* (in Adriatic) participated in VTC between USACOM and *Operation Restore Democracy* players (Haiti)
- Received live video of RPV conducting BDA at Fallon
- Morale booster

(U) Video teleconferences (VTCs) add a new dimension to the carrier's communications capability. During the predeployment FleetEx, *George Washington* and Second Fleet conducted VTCs twice daily. The first allowed the Second Fleet staff to observe the battle group morning briefs, and the second allowed the battle group staff to observe Second Fleet's afternoon briefs. Limited VTC capability at commands in the Mediterranean and Persian Gulf operating areas limited VTC use during the deployment, but, when available, VTCs offered significantly better staff-to-staff interaction than standard message traffic. The closer working relationship induced by VTCs contributed to a more expedient resolution of problems. Connecting the CNO VTC Information Exchange System (VIXS) with the Joint Worldwide Intelligence Communications System (JWICS) VTC would enable afloat staffs to interact with other components ashore as well as Joint Headquarters.

(U) As technology advances into the next century, the ability of a carrier to exchange video information will lead to many possible applications. The above slide suggests three from *George Washington*'s deployment that only begin to explore VTC's potential:

- **Contingency planning.** One contingency (never realized) called for COMCRUDESGRU TWO to support *Operation Restore Democracy* (Haiti). To learn about the situation, RADM Krekich and his staff monitored VTCs with USACOM and the *Restore Democracy* forces to increase situational awareness.

- **Remotely piloted vehicles (RPVs) or unmanned aerial vehicles (UAVs).** On one occasion, *Washington* received live video from an RPV conducting a battle-damage assessment test at Fallon, Nevada. As RPVs become operational, this may be a feature worth demonstrating further in the future.

- **Crew morale.** The use of VTC for crew morale is a new concept. Uses might include short family sessions (e.g., after the birth of a child), educational sessions, or counseling services.

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Telephones

- Official FOUO phones
  - » 24 lines; 17,371 hours (as of 31 Oct)
  - » $36,000 vs. $6,500,000 equivalent INMARSAT cost
  - » 50 to 100 hours equivalent INMARSAT time
  - » Other units had POTS access via battle group cellular
  - » Admin uses
  - » Potential for misuse
- Crew phones
  - » 8 lines
  - » Cost to crew was 50¢ per minute
  - » 958,800 minutes sold
  - » $40K to $80K profit for MWR
  - » OPSEC concerns

(U) *Challenge Athena II* supported 24 phones for official use only (FOUO). As of 31 October (the latest date for which we have data), official calls totaled over 17,000 hours of time at a cost of about $36,000. At INMARSAT's lowest rate ($6.25 per minute), the same number of hours would cost about $6,500,000. Of course, many calls would not have been made at INMARSAT's rate. Looked at another way, the $36,000 that bought 17,000 hours over *Challenge Athena* would buy only 50 to 100 hours on INMARSAT.

(U) The FOUO phones also reduced the INMARSAT bill for other members of the battle group. One line was reserved for battle group cellular users. *George Washington* served as a cellular net hub. Ships within 35 n.mi. of the carrier could access the reserved *Challenge Athena* line. But cost is not the only advantage. Ship's personnel could call shore offices when ordering supplies (e.g., replacement parts). Items were confirmed in stock before ordering, and orders were processed faster and more reliably than with message traffic. Direct contact also provided more accountability.

(U) The potential for phone misuse increases as the number of telephone lines available to the ship increases. A system (hardware and procedures, if not already in place) for controlling and policing access to off-ship lines would make life easier for the ship communication personnel tasked with overseeing telephone access.

(U) Eight telephone lines were made available for general crew use. Through an agreement with Sprint, crew members paid 50¢ per minute for calls anywhere in the 50 states or the Virgin Islands. Nearly a million minutes of time were sold—an average of three hours per crew member for the deployment. In addition, the carrier's Morale, Welfare, and Recreation (MWR) office received about $60,000 from the fees collected.

(U) Three times, *George Washington* exercised control over the crew phones to protect operational security (OPSEC). Crew phones were suspended after the death of a crewman, after a fire, and before the second southbound transit of the Suez Canal.

CNA

Challenge Athena II JDISS

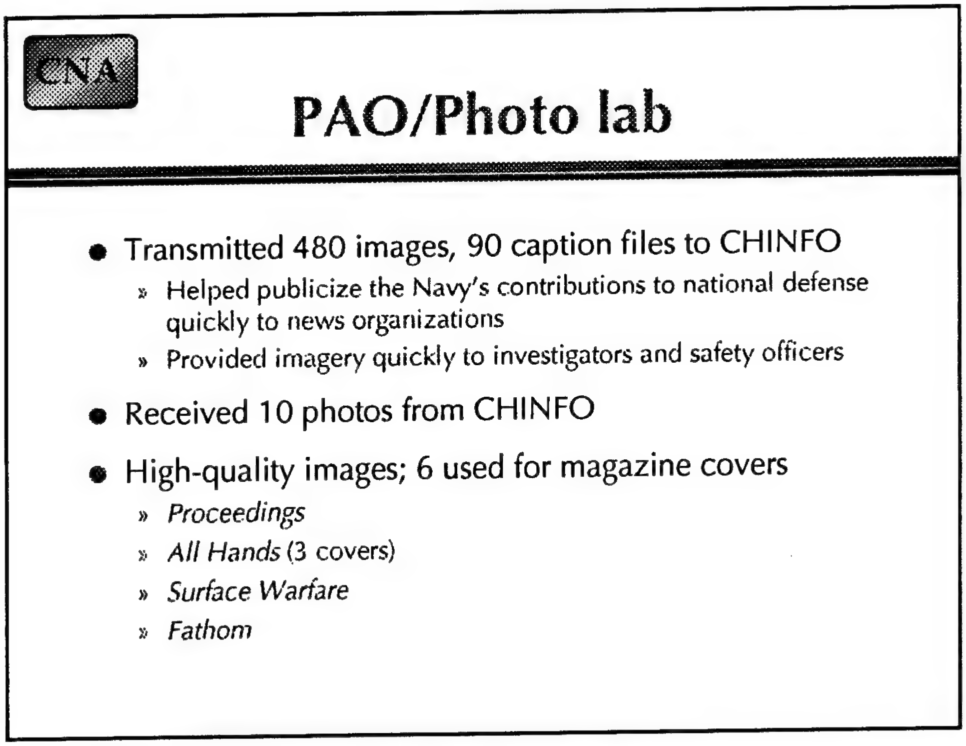
- Images transferred to MEUs (other ships with JDISS)
  - » 41 images sent
  - » Supported contingency planning
- Path for transmitting TARPS images
  - » 218 images sent
  - » High quality; better than otherwise available
- Better coordination with JAC, Molesworth, and CAOC, Vincenza

(U) *Challenge Athena II* supported JDISS systems at both the SCI and non-SCI levels. Both operated at a data rate of 56 kbps, compared to 9.6 or 32 kbps for the existing SCI JDISS already on *George Washington.*

(U) The SCI JDISS system allowed *George Washington* to transmit images to other JDISS users who could not otherwise obtain recent imagery. In all, *George Washington* sent 41 images to two separate MEUs deploying to Somalia. The current imagery was valuable to the MEUs because it showed recent developments and allowed the Marines to familiarize themselves with landing zones, port facilities, and potential ambush sites. They also were able to plan contingencies (e.g., evacuation operations).

(U) The JDISS system allowed *George Washington* to send 218 digital TARPS images to JAC, Molesworth, and other commands. A VECXEL scanner, provided by Navy TENCAP, allowed the digitizing of TARPS negatives, which were then sent over JDISS. The resulting image quality was much better than otherwise available from current procedures. TARPS images in the Mediterranean were sent to the Combined Air Operations Center (CAOC) in Vincenza, Italy, whereas those in the Persian Gulf were sent to JTFSWA. Without Genser JDISS, images would have been hand-carried from the carrier to the appropriate command.

(U) The high data rate for the *Challenge Athena* SCI JDISS resulted in better coordination between *George Washington* and other commands. E-mail and chatter with JAC, Molesworth, facilitated changes to the imagery target deck. *George Washington* pulled message traffic to stay current on events in other potential operating areas. Without the capability to transmit images up-echelon over JDISS, hand-carry of hard-copy film from the carrier to the shore would have been necessary.



(U) The Public Affairs Office (PAO) and Photo Lab on *George Washington* used a 64-kbps line to exchange digital images and text with CHINFO and other Pentagon offices. Overall, they sent 480 images with 90 caption files. They received ten images from CHINFO.

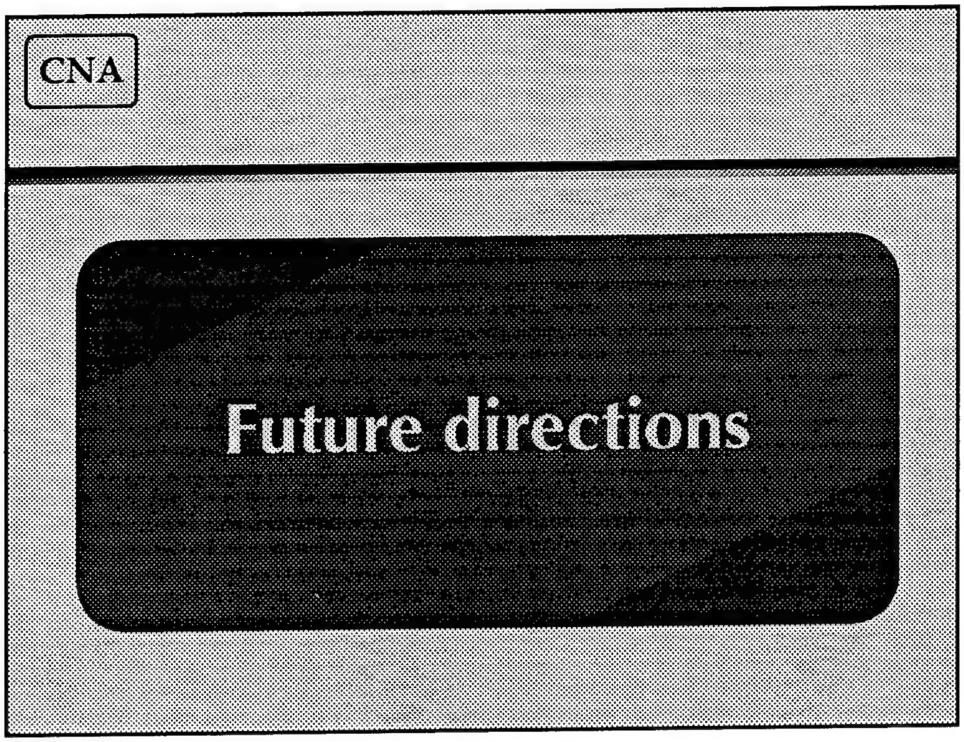
(U) One role for the PAO connectivity is to publicize the Navy's contributions to national defense, either to inform or preempt commercial news organizations. The *Challenge Athena* connectivity gives the Navy an on-the-spot news reporting capability.

(U) The quality of the images sent back to CHINFO was high. The Naval Institute's *Proceedings* used one image, shown in the next slide, for the cover of its August 1994 issue. Because the high-resolution picture was digital, the Institute used the figure directly without having to scan from a hard copy or touch it up to remove blemishes. *George Washington,* therefore, demonstrated the ability to send a product suitable for immediate publication from a deployed carrier to a CONUS office. Images from *Challenge Athena* also appeared on five other magazine covers.

CNA

Proceedings cover, Aug 1994

To view this slide, please refer to the complete (and classified) version of CNA Annotated Briefing 95-11.



(U) Based on the successes of *Challenge Athena I* and *II*, wideband commercial satellite communications may be installed on all major platforms, including carriers, big-deck amphibs, and command ships. How multiple ships, possibly operating in multiple theaters, share one or more satellites effectively will be an issue for CONOPS resolution.

(U) *Challenge Athena III* is already being planned for the Pacific deployment of USS *Carl Vinson*. Additional ships (USS *Belleau Wood* and USS *Blue Ridge*) will share the connectivity if adequate funding is obtained.

(U) In this section, we discuss the possible direction of future demonstrations and analysis issues rising from these demonstrations.

CNA

Theater issues

- *Challenge Athena* as enabling technology
- Multiple ships in broadcast
  - » Flexible bandwidth
  - » Increase bandwidth?
- Joint operations
  - » Demo CJTF or JFACC afloat
  - » Other services as users
  - » Allied operations
  - » Demo of CTAPS (ATO generation), TIBS, LOCE, JWICS/VIXS
  - » Disadvantaged units
- Demonstrate capability in other regions (PACOM)
- Worldwide operating requirements

(U) *Challenge Athena* has demonstrated that it is an enabling technology. It has much to offer a battle group operating on its own or as part of a larger operation.

(U) The obvious next step is an operational deployment with several ships using the communications bandwidth. The primary issue is how they will share the connectivity. All of them will receive the satellite's transmission, but how will the uplink function? Will each ship be given a fixed bandwidth for transmission, or will it vary as operations require? A priori, the latter seems preferable. Also, will the combined need for imagery overload the system capability? Is a larger bandwidth necessary? (T2, or 6.176 Mbps, may be possible with a slightly larger antenna or a higher power satellite transponder.)

(U) *Challenge Athena* will allow Navy units to operate more effectively in joint operations. Steps leading to the demonstration of a CJTF or JFACC afloat include setting up a link with another service or an ally. If a CTAPS is installed on the carrier, *Challenge Athena* can be used to transmit a daily ATO from an afloat unit. In addition, because of its wideband capability, *Challenge Athena* may offer a path for exchanging information with disadvantaged units (those with limited communications capability).

(U) Despite the current successes, demonstrations in other areas (most notably PACOM) are desirable. Operations in different geographic areas might raise different operational issues. As more ships share the bandwidth, *Challenge Athena* may have the chance to support ships operating in disparate areas simultaneously.

(U) A long-term issue is how many satellite transponders will be necessary to support a *Challenge Athena*-like connectivity on a continuing basis, worldwide, on a number of ships. If each "large" ship has the connectivity, is one transponder per satellite always sufficient? Given current deployment schedules and areas of interest, is worldwide coverage necessary or possible? How much will it cost, total and on a per ship basis? Will the money be there to fund it? Will the theater pay for it?

CNA

Application issues

- Maximize utility of telecommunications
  - » Live video from air wing aircraft
  - » Receive RPV/UAV video
  - » VTC ability to aid contingency planning or situational awareness
  - » Battle group cellular options (digital cellular hookup to Link 11?)
- Vary bandwidth for large users (e.g., for imagery)
  - » Set system robustness by application; power vs. bandwidth tradeoff
- Unclassified VTC
  - » Medical consultations
  - » Training or education sessions
  - » Technical support (possibly with a mobile camera)
- Move admin functions to shore

(U) The potential for a *Challenge Athena*-like connectivity is nearly limitless. In particular, it offers telecommunication opportunities that could not be envisioned previously. For example, the technology now exists to receive and distribute live video from air wing aircraft or RPVs. The VTC capability allows face-to-face interaction between dispersed commands within the same theater and around the world. Battle group cellular can extend *Challenge Athena* connectivity to other platforms, and a digital capability may allow ships to share Link 11 data more reliably.

(U) During *Challenge Athena II*, imagery receipt used a fixed portion (half) of the bandwidth. Increases in user demands or changing requirements may necessitate smaller or larger bandwidth allocations for imagery. Future efforts should focus on receiving imagery at different data rates to allow maximum flexibility in dynamic management of the bandwidth. Because other applications can function well with higher error rates, a better use of bandwidth may be to reduce the allocation of some applications (voice lines, in particular) to make more available for other purposes.

(U) An unclassified VTC system would expand the VTC capability among a wider audience. For example, doctors could consult with specialists ashore. *Challenge Athena II* indicated that conducting psychiatric evaluations in this manner could further reduce the number of MEDEVACs. Because this use would only be part time, the system could meet other needs, including training or education sessions. A link with a mobile camera could permit shore personnel to provide technical support anywhere on board a ship.

(U) An independent effort is under way in the Pacific to use a capability similar to *Challenge Athena* to handle administrative functions (e.g., PSD support) from shore. The idea is to reduce the number of deployed administrative personnel without losing their services. A corresponding effort can be included in future *Challenge Athena* demonstrations.

CNA

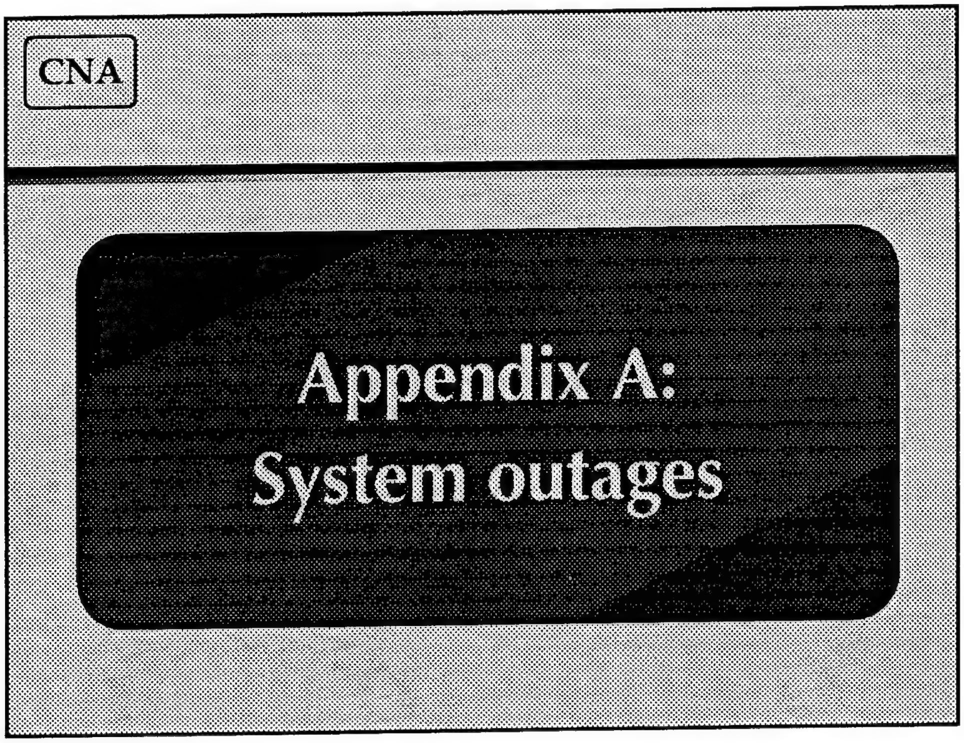
Technology issues

- SPY-1 EMI
  - » RAM balls or fence about antenna
  - » Positioning strategies
  - » Improved sectoring capability
  - » Frequency restriction
  - » Better radome
- Antenna technology
  - » Dish size
  - » Optimal placement on carriers, amphibs, and command ships
- Limit loss to primary imagery
  - » Printout flaws
  - » Fuze surrounding pixels

(U) The most notable technology issue is EMI from SPY-1 radars. Several possible solutions are being considered. An option used at some shore facilities places radiation-absorbent material (RAM) around the receive antenna, either in the form of disks attached on the rim of the dish or in the form of a fence around the radome. Positioning strategies offered some relief from EMI, but restricted Aegis positioning around the carrier. Further thought on this tactic may yield a solution. Sectoring the SPY-1 radar did not work consistently during *Challenge Athena II.* The current belief is that the SPY-1 sectoring technique does not work well. The Aegis program is looking into improvement options. Another proposal suggests restricting the frequency band used by the SPY-1 to reduce EMI. How this would affect SPY-1 performance is not yet clear. Other options include replacing the current radome with one better suited for EMI reduction, and using Reed-Solomon encoding. Formal (i.e., sponsored and funded) testing is needed to explore the EMI issues fully.

(U) Antenna technology is advancing. As satellite transceivers become smaller or conformal, ships will be able to install antennae in more places. Even so, locating the best spot for the antenna, while avoiding interference with ship operations, will continue to be a challenge.

(U) Flawed images, although common, were not a significant problem for the *Challenge Athena II* demonstration. Future demonstrations may experience greater loss. Two methods seem viable to minimize this loss. The flaw in a FAF block may affect only a few pixels. Currently, the entire FAF block is blanked out on the image. One option is to print the FAF block including the flaw. A trained photo interpreter will recognize the flaw for what it is and still have access to the undamaged pixels. A second option is to use a software algorithm to recover the original data using adjacent undamaged pixels. Additionally, an image may be retransmitted until satisfactory coverage is obtained.



(U) This appendix contains a table of *Challenge Athena* system outages between 20 May and 29 October 1994. By system outage, we mean no application was able to function over the *Challenge Athena* communications path.

Table 1. *Challenge Athena II* system outages

Unclassified

DTG of outage	Cause of outage	Duration of outage (min)
200130-200150Z May 94	Antenna blockage	20
211210-211230Z May 94	Lost satellite track	20
230610-230730Z May 94	Low Eb/No	80
231005-231012Z May 94	Low Eb/No	7
241005-241012Z May 94	Antenna blockage	7
272045-272348Z May 94	Antenna blockage	3
281950-281958Z May 94	Loss of clocking	8
311623-311630Z May 94	Bad weather at Holmdel gateway	7
010955-011221Z June 94	Antenna blockage	146
140855-140858Z June 94	Antenna blockage	3
161010-161148Z June 94	Antenna blockage	94
171204-171218Z June 94	Antenna blockage	14
190235-190251Z June 94	Disconnected circuits	16
200120-200150Z June 94	EMI	30
201400-201405Z June 94	Lost RCX carrier	5
210605-210625Z June 94	Lost RCX carrier	20
210645-210718Z June 94	EMI	33
211510-211514Z June 94	Lost carrier	4
211617-211753Z June 94	EMI	96
212118-212132Z June 94	EMI	14
240930-240936Z June 94	EMI	6
241940-241951Z June 94	EMI	11
251840-251845Z June 94	Unknown	5
252236-252241Z June 94	Reset Timeplex cards	5
271005-271017Z June 94	Power loss/lost satellite track	12
061010-061035Z July 94	Lost satellite track	25
061725-061733Z July 94	Reset Timeplex cards	8
070745-070802Z July 94	Lost satellite track	17
071330-071405Z July 94	Antenna blockage	35
071440-071545Z July 94	Antenna blockage	65
071630-071636Z July 94	Antenna blockage	6
071850-071925Z July 94	Antenna blockage	35
072020-072026Z July 94	Antenna blockage	6
072235-072305Z July 94	Antenna blockage	30
090020-090100Z July 94	Unknown	40

Table 1. *Challenge Athena II* system outages (continued)

Unclassified

DTG of outage	Cause of outage	Duration of outage (min)
090415-090805Z July 94	Timing at Holmdel	230
091225-091448Z July 94	Timing at Holmdel	23
091720-091755Z July 94	Timing at Holmdel	35
100135-121345Z July 94	Timing at Holmdel	2170
121840-121935Z July 94	Lost T1 btwn NCD, Ft. Belvoir	55
141102-141108Z July 94	Lost carrier	6
141840-141845Z July 94	Unknown	5
141930-142000Z July 94	Restarted cards	30
161039-161049Z july 94	Low Eb/No	10
161930-161950Z July 94	Modem reset	20
180015-180028Z July 94	Fluxuation in power	13
180255-180330Z July 94	EMI	35
181506-181510Z July 94	EMI	4
191250-191255Z July 94	Unknown	5
210830-210834Z July 94	Disconnect at NJ	4
220830-221219Z July 94	EMI	229
221326-221356Z july 94	EMI	30
221500-221730Z July 94	EMI	150
221950-222000Z July 94	Lost satellite track	130
232237-232300Z July 94	Loose connection in radio	23
242005-242030Z July 94	Fluxuation in RCX power	25
250450-250537Z July 94	EMI	47
250544-250800Z July 94	EMI	136
251423-251605Z July 94	EMI	102
251855-260052Z July 94	EMI	357
261015-261020Z July 94	Low AGC	5
271810-271824Z July 94	EMI	14
271825-271840Z July 94	EMI	15
301945-302005Z July 94	Fluxuation in RCX power	20
011917-011915Z Aug 94	Lost satellite track	2
012204-012243Z Aug 94	EMI	39
020005-020025Z Aug 94	Lost modem lock	20
022014-202030Z Aug 94	EMI	16
022247-022351Z Aug 94	EMI	64
032311-040219Z Aug 94	Antenna blockage	187

Table 1. *Challenge Athena II* system outages (continued)

Unclassified

DTG of outage	Cause of outage	Duration of outage (min)
040832-041630Z Aug 94	Bad antenna coupler at Holmdel gat	478
061945-062057Z Aug 94	Lost satellite track at Holmdel	72
072040-072049Z Aug 94	EMI	9
072300-072340Z Aug 94	Lost satellite tracking	40
080256-080351Z Aug 94	EMI	55
081550-081600Z Aug 94	Lost satellite tracking	10
082020-082050Z Aug 94	Antenna blockage	30
110808-110838Z Aug 94	Lost power to equipment	30
130224-130231Z Aug 94	Antenna blockage	7
130240-130315Z Aug 94	Antenna blockage	35
1305005-130510Z Aug 94	Antenna blockage	5
130605-130618Z Aug 94	Antenna blockage	13
140035-140042Z Aug 94	Lost satellite track	7
140430-140635Z Aug 94	Disconnected by Bell Co.	125
160443-160535Z Aug 94	Antenna blockage	52
170045-170052Z Aug 94	Lost satellite tracking	7
170450-170510Z Aug 94	Antenna blockage	20
180055-180200Z Aug 94	Faulty tracking converter	65
210915-210935Z Aug 94	ACU Fault	20
271045-271050Z Aug 94	Lost RCV carrier	5
271805-271930Z Aug 94	EMI	85
291820-291840Z Aug 94	Lost satellite tracking	20
291932-291942Z Aug 94	Lost CX track	10
311706-311715Z Aug 94	Antenna blockage	9
050150-051525Z Sep 94	HPA burned out	875
090700-090720Z Sep 94	Lost satellite track	20
121503-121703Z Sep 94	Burned out cable at Holmdel	120
131503-131515Z Sep 94	Lost satellite track at Holmdel	12
141830-141930Z Sep 94	Lost satellite track at Holmdel	60
150845-150855Z Sep 94	Lost satellite track	10
161627-161805Z Sep 94	Loose cable on ACU	98
180001-180105Z Sep 94	Bad weather at Holmdel	64
211147-211150Z Sep 94	Reset cards	3
221705-221731Z Sep 94	RCX problem at Holmdel	26
222048-222105Z Sep 94	Antenna blockage	17

Table 1. *Challenge Athena II* system outages (continued)

Unclassified

DTG of outage	Cause of outage	Duration of outage (min)
230621-230657Z Sep 94	Antenna blockage	36
230715-230945Z Sep 94	Antenna blockage	150
031011-031017Z Oct 94	EMI	6
031120-031130Z Oct 94	EMI	10
031316-031337Z Oct 94	EMI	21
041604-041610Z Oct 94	EMI	6
101405-101515Z Oct 94	EMI	70
111050-111110Z Oct 94	EMI	20
112213-112230Z Oct 94	EMI	17
120850-121440Z Oct 94	EMI	350
130800-131025Z Oct 94	EMI	145
151110-151330Z Oct 94	EMI	140
212101-212230Z Oct 94	Corrupted Timeplex at NCD	140
221245-221325Z Oct 94	Hung Timeplex at NCD	40
231250-231330Z Oct 94	Low satellite power	40
251820-251830Z Oct 94	Lost satellite track	10
290250-291440Z Oct 94	EMI	710
	Total outage time (min)	**9,614**
	Percent reliability through 29 Oct	**96%**

CNA

Appendix B: Electromagnetic compatibility

(U) Receiving primary imagery requires a bit error rate (BER) of less than 10^{-6}, although other applications can sustain much higher error rates without significant degradation. Because the U.S. Navy has not used communications systems in these frequency bands before,[1] *Challenge Athena II* was a unique opportunity to explore the electromagnetic compatibility of this commercial equipment with typical carrier battle group operations.

(U) Electromagnetic compatibility refers to the following:

- Radiation hazard (RADHAZ) to personnel
- Hazards of electromagnetic radiation to ordnance (HERO)
- Electromagnetic interference (EMI).

The Naval Surface Warfare Center (NSWC) staff conducted postinstallation testing from 26 through 28 March 1994. With the ship moored to Pier 11 at Naval Station, Norfolk, Virginia, NSWC staff established the RADHAZ and HERO conditions created by the *Challenge Athena II* transmitter. Observations made throughout the workups and deployment of USS *George Washington* ascertained the level and conditions of EMI caused by onboard and offboard emitters. This appendix summarizes what was found.

1. Transmit ≈ 6.0 GHz/receive ≈ 4.0 GHz.

RADHAZ

(U) RADHAZ refers to the hazard a particular emitter might pose to personnel who come near it. NSWC, Dahlgren, Virginia, used a permissible exposure limit (PEL) of 5 mW/cm^2 for six minutes as the acceptable criterion for this system. The RADHAZ measurements were made with a NARDA Microwave Corporation Model 8616 Broadband Isotropic Radiation Meter equipped with a NARDA Model 8623C High-Frequency Isotropic Probe that had an operating range of 0.3 to 26 GHz. During the testing, the satellite terminal was operated in a maintenance, or unlinked mode, having the following parameters:

- Antenna gain of 41.72 dBi
- Transmit power of 125 Watts (actual transmit power used in *Challenge Athena* was 81.3 Watts)
- Transmit frequency of 6.32 GHz
- Transmit beamwidth of 1.47 degrees
- Antenna diameter of 7.9 feet.

(U) With the antenna at its minimum operating elevation of 18 degrees, the only condition that exceeded the PEL was when the antenna was at a relative bearing of 000 degrees. This condition occurred about 2 feet onto the flight deck. Furthermore, normal operation of the transmitter requires the presence of a received signal. If a person should get in front of the antenna while it is radiating, the receive signal would be blocked and the transmitter would shut down. NSWC concluded that there should be no RADHAZ concerns during routine operations.

HERO

(U) HERO refers to the possible hazards to ordnance that electromagnetic energy from the transmitter might incur. These hazards vary with the type of ordnance and the radio frequency (RF) of the radiation. Electrically initiated ordnance falls into three categories:

- Safe
- Susceptible
- Unreliable/unsafe.

The difference between the classifications is the level of RF energy at which the ordnance is susceptible to malfunction. Such an event may be classified as either a "safety" or an "operational" malfunction. For HERO-susceptible ordnance, the level of RF energy at which the ordnance becomes susceptible varies with the frequency of the energy. Only the *Challenge Athena* transmitter frequency was considered for this test.

In addition to susceptibility levels, we reviewed the ship's ordnance loads as well as where ordnance is handled and loaded. We used NSWC Report, *Hazards of Electromagnetic Radiation to Ordnance Assessment of USS* George Washington *(CVN-73)*, dated September 1992, for that purpose.

(U) Generally, a particular piece of ordnance is tested in an electromagnetic environment to determine its classification. If testing cannot be accomplished, computer models are used to predict the classification. Such models are designed to be conservative. For each RF, each classification carries with it a maximum power flux density beyond which the ordnance may become susceptible. The following were the criteria for the 6.0-MHz transmitter used in *Challenge Athena II*:

- HERO safe: 100 mW/cm^2
- HERO susceptible: 2.28 mW/cm^2
- HERO unsafe: 1.14 mW/cm^2.

(U) A review of the above data reveals that the HERO-susceptible criterion of 2.28 mW/cm^2 was not exceeded on the flight deck with the antenna operating at its normal elevation angle of 18 degrees. For a transmitted power of 125 Watts, however, no HERO-susceptible ordnance should be within 112 feet of the antenna when the elevation angle is less than 18 degrees. This criterion applies to the following items likely to be found on a carrier:

- Walleye guided weapons (Mk 30 Mod 6 and above and Mk 34 through 37)
- NALC M161 when used in the emergency flotation system on the UH-2A, in the BQM-74C, and in the TDU-21/A, TDU-SS/A, and A/A 37U–31 towed targets.
- NALC M182 Aircraft Fire Extinguisher Cartridge on the SH-3
- NALC M514 Cartridge for the AQM-37A Target Drone.

Of these, most were either not carried on board *George Washington* or were not normally carried by the air wing. The M182 cartridge, however, was installed in all SH-3 helicopters; so initially, the system was restricted to radiating in such a way as to avoid an SH-3 flying through the main beam at ranges less than 128 feet from the antenna. This criterion was based on modeling. At the direction of COMNAVAIRLANT (COMNAVAIRLANT 050134Z APR 94), the M182 Cartridge was tested and found to be HERO-susceptible (unrestricted). Although these cartridges retain the susceptible label, the effective threat ranges were reduced so HERO EMCON was no longer needed when SH-3 aircraft operated within the radio/radar envelope of aircraft carriers. The cartridges do, however, remain in the HERO-susceptible (restricted) category during handling and installation/removal and do require HERO EMCON. Because this activity takes place on the flight deck and the main beam of the *Challenge Athena II* system does not impinge on the flight deck, no such control is required.

(U) During the course of the deployment, which began on 20 May 1994, the output of the high-powered amplifier (HPA) was reduced to a final value of 81.3 Watts, where it remained. Although this transmitter power was sufficient for the Earth station to receive a clear signal from the ship, the radiation patterns thus created would have reduced the readings taken during March in the port period summarized above. All test results reported here are conservative by 35 percent.

EMI

(U) Although no emitters within the battle group had designed transmission frequencies in the receive range of the *Challenge Athena II* system, two radars—the AN/SPS-48C and the AN/SPY-1—were sufficiently powerful to have spectra overlapping the receive envelope.

AN/SPS-48C

(U) This radar is found on all aircraft carriers as well as on most other capital ships. It is a three-dimensional long-range air search radar that operates at a variety of frequencies, the highest of which is still below the receive frequency of C-band commercial SATCOM. It has four main operating power modes: "First Stage" (3 kW), "Second Stage" (60 kW), "Driver" (600 kW), and "Final" (2.2 MW). Only operation in "Final" created a transmission spectrum broad enough to interfere with the SATCOM receiver. This noise was periodic, arriving for a short period every four seconds—the scan period of the SPS-48C. Only the primary imagery delivery circuit was affected because the BER would climb to between 10^{-5} and 10^{-4}. Any image received while the SPS-48 was in "Final" had many small, gray squares on the image. These squares were individual blocks of data that contained errors. The capture algorithm developed by the Air Force rejects all pixel data in any block where at least one pixel has an error. Other algorithms exist for averaging pixel data around the affected pixel without rejecting the others, but such an algorithm has not been implemented.

(U) Shifting to satellite transponders with higher operating frequencies reduced the level of EMI and improved the BERs to about 10^{-5}. To quantify the interaction between the radar and the *Challenge Athena II* receiver, at-sea tests were run from 26 to 27 March with the *Challenge Athena II* transmitter off. The antenna rotated around the horizon at different elevation angles with the receiver tuned to different transponders. Then, because some members of the *Challenge Athena II* team believed that radiation from the radar might be entering the system through the various RF joints, aluminum foil was carefully wrapped around them and the tests were performed again. The higher frequencies offered some relief from the SPS-48 EMI, but the aluminum foil did not.

(U) Similar interference has occurred at land-based SPS-48 installations, and NSWC, Dam Neck, Virginia, has developed a notch filter to help alleviate it. Such a filter was built and installed on *George Washington*. It ended any further interference from the SPS-48.

AN/SPY-1

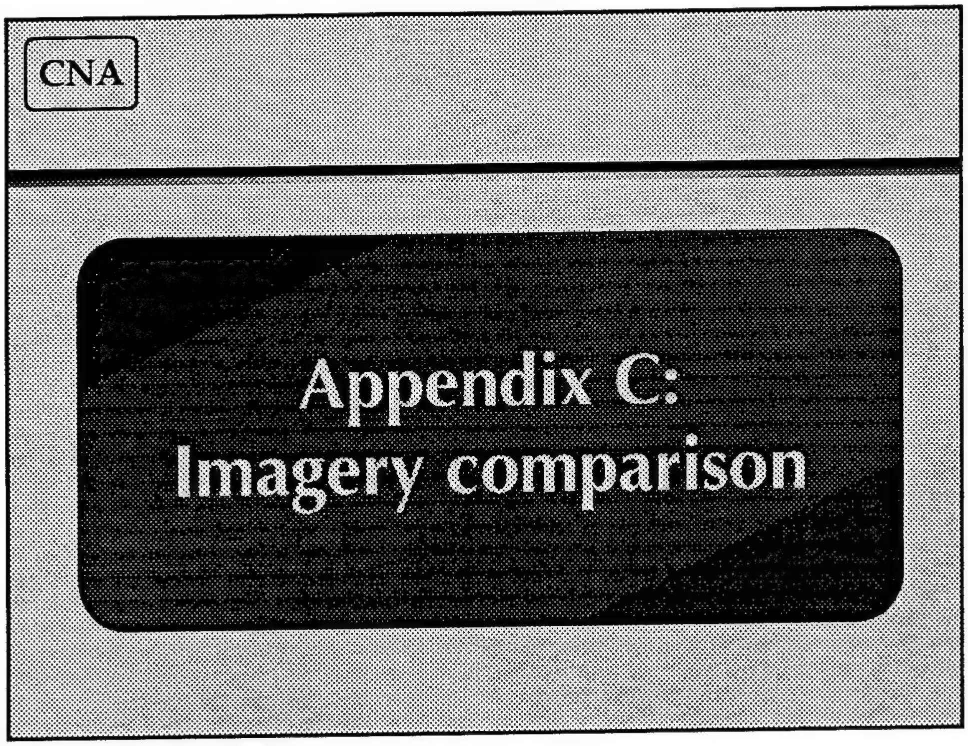
(U) This radar is the main active sensor of the Aegis Weapons System and is found only on Aegis-class cruisers and *Arleigh Burke*-class destroyers. Two of the former (USS *Thomas S. Gates* (CG-51) and USS *San Jacinto* (CG-56)) and one of the latter (USS *Barry* (DDG-52)) were attached to the *George Washington* battle group. These radars can transmit peak powers on the order of 6 MW, which results in very broad transmission spectra that overlap the receive band of commercial C-band SATCOM. They generate sufficient power to cause interference within the line-of-sight. Given the heights of the antennas, this is about 27 n.mi. BERs greater than 10^{-3} are not uncommon when the radar is about half way to the horizon (about 15 n.mi.). This much interference is sufficient to affect even the telephones. Frequently, crypto synch is lost and images cannot be received at all. On one occasion (12 April, before the deployment), the radar was 8 to 10 n.mi. off the port quarter of *George Washington*. The interference was so strong that the modem dropped synch and the antenna slewed around and started to track the SPY-1, causing the complete loss of all *Challenge Athena II* communications.

(U) The SPY-1 has a history of interfering with commercial C-band SATCOM equipment. To eliminate interference near the U.S. Virgin Islands, transmission restrictions are placed on SPY-1 ships operating in the vicinity. Unfortunately, no notch filter has been designed for the SPY-1. The radar, however, is capable of blanking its transmitter in selectable sector widths. Furthermore, during *Challenge Athena II*, the antenna was mounted on the Four Channel INMARSAT Sponson below the flight deck. In this location, the carrier's hull can provide protection if the radar is kept off the starboard side. Finally, the radars can be operated at ranges greater than 27 n.mi. with almost no interference at all on most occasions, but the presence of strong surface evaporative layers can allow the radiation to be seen at much greater ranges.

(U) Although these operational workarounds are marginally tolerable for a demonstration, they are totally unacceptable for Navy-wide operations. The fleet requires the flexibility to use its sensors and weapon systems as the situation dictates without regard to EMI problems. Hence, if commercial C-band SATCOM is to be integrated into Fleet operations, the SPY-1 transmission spectrum will have to be reduced in amplitude near the SATCOM receive band. Due to the basic design of the radar, this will be difficult. The best solution appears to be selected modifications of the SATCOM receiver system.

These modifications might include the following:

- Addition of radar-absorbent materials (RAM) around the antenna edge to reduce EMI
- Addition of RAM fences around the sponson to eliminate entry paths for radiation arriving at low elevation angles
- New forms of forward error correction (FEC) coding to ensure that corrupted bits can be restored without disruption
- Precise grooming of SPY-1s to ensure that sector blanking is effective
- Frequency management to ensure that the radars operate as far from the assigned downlink frequency as possible
- Maximization of downlink power to achieve the greatest signal-to-noise ratio possible.



(U) Despite the existence of large, archival imagery databases, some missions in areas of heightened interest will require frequent updates. In particular, afloat forces will need timely, high-quality imagery (together with mensuration data) for mission support. This appendix contrasts primary and secondary imagery, their relative image sizes, and the time each type requires for transmit to an afloat user.

(U) Briefly, primary imagery is unexploited, "raw" imagery. It is near-original quality and maintains the mensuration coefficients (i.e., the ability to measure relative distances on the image and to do geolocation). Primary imagery is classified SCI.

(U) Secondary imagery has been exploited and annotated by imagery analysts at a theater intelligence center and does not contain the ESD. It also may be near-original quality. Secondary information is transmitted at the non-SCI level.

(U) TLAM-C/D Digital Scene Matching Area Correlator (DSMAC) scenes must be derived from primary imagery products. These scenes, therefore, must be obtained before any operations degrade them. The Defense Dissemination System III's (DDS III's) processing segment is the starting point for all imagery. It sent primary images directly to *George Washington* during *Challenge Athena*.

Building an image

To view this slide, please refer to the complete (and classified) version of CNA Annotated Briefing 95-11.

(U) To read the text associated with this slide, please refer to the complete (and classified) version of CNA Annotated Briefing 95-11.

Size comparison

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Appendix D: *Challenge Athena II* costs

(U) This appendix summarizes the costs for the *Challenge Athena II* demonstration. These costs fall into one of two categories:

- Nonrecurring—one-time only, fixed costs such as purchase, installation, and integration of the shipboard antenna and hardware
- Recurring—costs that accrue on a regular basis such as monthly rental of the satellite transponder and landline connections.

Nonrecurring costs

(U) The total installation cost was $1.44 million. All installation costs were incurred by the national community with Congressional funds, with the exception of the imagery receive equipment, which was paid for by the U.S. Air Force. The imagery receive equipment, called the System Test Tool, included the imagery processing system, its associated hardware (disk drives, printer, uninterruptible power supply), and communications support (crypto, patch panel, interfaces). Table 3 shows a breakdown of the costs.

Table 3. Nonrecurring costs

Unclassified

Item	Cost ($)
Shipboard antenna	250,000
Shipboard hardware	92,000
Installation/integration	300,000
Imagery receive equipment	800,000
Total	**1,442,000**

Recurring costs

(U) *Challenge Athena*'s total monthly recurring cost was $208,000 (compared with a typical monthly INMARSAT bill of $75,000). The commercial satellite communications (SATCOM) link included short-term (i.e., monthly) leasing of a C-band (4 to 8 GHz) transponder. This arrangement is unusual. Most SATCOM transponder leases are long term (i.e., greater than five years). *Challenge Athena* also had to lease the landlines to connect the commercial SATCOM gateway with the Navy users and applications. Table 4 shows a breakdown of these costs. Based on a six-month deployment and two-month workup period, the total recurring costs were $1.66 million.

Table 4. Recurring costs

Unclassified

Item	Cost ($/month)
Satellite transponder	123,000
Earth station/landline	85,000
Total	**208,000**

Future costs

(U) Navy Space Systems Division (OPNAV N633) obtained the funding for *Challenge Athena II* from the Congressional Targeting Initiatives through the Office of Deputy Assistant Secretary of Defense (Intelligence and Security). Currently, fleetwide discussions regarding the prioritization and funding for *Challenge Athena*-like systems include various options for funding non-recurring and recurring costs.

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